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Soil moisture dynamics and plant transpiration under contrasting annual-perennial cover types

Matt Helmers
Iowa State University, mhelmers@iastate.edu

Heidi Asbjornsen
Iowa State University, hasbjorn@iastate.edu

Amy L. Kaleita
Iowa State University, kaleita@iastate.edu

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Abstract
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Keywords
Agricultural and Biosystems Engineering, Corn-soybean cropping systems, Cover crops double crops strip cropping, Soils and agronomy, Water quality quantity and management

Disciplines
Agronomy and Crop Sciences | Bioresource and Agricultural Engineering | Water Resource Management

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Principal Investigator:

Matt Helmers
Agricultural and Biosystems Engineering
Iowa State University

Co-investigators:
Heidi Asbjornsen
Formerly Iowa State University,
now University of New Hampshire

Amy Kaleita
Agricultural and Biosystems Engineering
Iowa State University

Budget:
$44,725 for year one
$32,663 for year two

Q How does a range in vegetation types influence soil moisture dynamics?

ECOLOGY

A These results show that diversified LEI systems can produce yields and profits that match or exceed those obtained from conventionally managed corn-soybean systems. Additionally, we learned that ecological processes such as weed seed consumption by rodents and insects can promote effective weed control in LEI systems, while allowing substantial reductions in herbicide use. Weed seed losses to rodents and insects can be enhanced by delaying tillage operations to leave seeds on the soil surface for as long as possible.

Background

The introduction of annual crops such as corn and soybeans in place of perennial plant communities in much of the Midwestern landscape has altered the natural hydrology of the region's ecosystem. In much of the upper Midwest, annual crops are planted in the spring and there is little plant growth until late spring or early summer. Spring also features periods of higher rainfall. It is expected that annual field crops will have different water use characteristics than perennial plants, and thus soil water conditions under each vegetation type also will differ.

Despite these expectations, there is little information about the soil moisture dynamics of contrasting vegetative types or land uses in the Midwest. Yet interest is growing in the use of perennial plants as a feedstock for ligno-cellulosic biofuel production, and in restoration of native prairie areas. Correspondingly, there is a need to understand how water use functions in these systems to better estimate the positive or negative effect these introductions might have on water quality and water resources.

The project objective was to quantify 1) soil moisture dynamics within the root zone and 2) plant transpiration under contrasting annual-perennial plant communities.

Approach and methods

Quantification of the effects of plant community diversity and functional group composition on soil moisture and plant transpiration dynamics was conducted in replicated treatments at the ISU Agronomy and Agricultural Engineering Research Farm west of Ames. Prior to the establishment of the treatments, this area was under a corn-soybean rotation, so the treatment history on all the plots was similar. Since the plots were recently established and have similar topography, it is expected that differences in soil moisture dynamics between treatments will be primarily due to land use or plant community differences.

Instruments

Sixteen different treatments were studied including corn, soybeans, brome grass, switchgrass, winter cover crops in a corn-soybean system started in 2007, and four different native perennial species both in monoculture and polyculture plots (big bluestem, Canada wild rye, false blue indigo, and stiff goldenrod). Soil moisture dynamics under contrasting annual-perennial plant communities were investigated during the growing seasons of 2007 through 2009.

Results and discussion

The project objective was achieved by field studies examining the main hypothesis that perennial plant communities will use water differently throughout the year, thereby increasing water storage capacity within the soil profile, especially during periods when there is the greatest susceptibility for surface runoff and leaching of water below the plant root zone (i.e., late spring and early summer).

Overall, soil water storage within the root zone is higher in spring and fall than in summer, responding to field soil moisture conditions and rainfall input as well as water use by plants. Soil moisture and water storage showed temporal variation over the growing season with higher variation during the early growing period, especially for the plots with perennial plant covers. Soil water storage and its temporal change rose as precipitation increased.

Overall, the annual row crops (corn and soybean) did not show higher water storage than the perennial plants in the study plots based on the data. However, the continuous soil moisture monitoring indicated that perennial plants likely use more water during the early summer (June) and, therefore, have lower water storage than annual row crops during most of summer. The greater use of water in the growing season by perennial plants could lead to lower soil moisture within the root zone and increased soil water storage capacity, which allows for more storm water being held within soil profile. Switchgrass showed less decrease in soil water storage during the growing season than other perennial plants. Sap flow monitoring indicated similar plant transpiration rates for big bluestem, stiff goldenrod, and false blue indigo at a site where plant density was similar for these species.

Conclusions

The study results suggest that perennial cover crops could be used to reduce soil water storage content or soil water storage during the growing season, thereby increasing the soil water storage capacity for subsequent rainfall events. This is important in reducing surface/subsurface flow and nutrient loss from the agricultural fields, particularly in the spring to early summer periods when perennial plants use more water. Some mixed prairie systems likely have higher water use than a single plant cover system and, therefore, have less soil water storage within the root zone.

Impact of results

The project results have increased knowledge of soil moisture dynamics under varying land covers. This information is essential for understanding how current

View of plots

and future management practices impact water flow and, more specifically, quantities of water flow. It is particularly important to document potential soil water storage changes throughout the year and to establish that perennial-based systems have potential to reduce soil water storage during critical periods, such as early in the year before annual crops use much water.

Education and outreach

Publications:

- Hancheck, Emily. Soil moisture dynamics and plant transpiration of contrasting annual and perennial plant communities. Thesis, expected spring 2013.
- Zhou, X., E. Hancheck, M. Helmers, H. Asbjornsen, and A. Kaleita. Soil moisture dynamics of contrasting annual and perennial plant communities. To be submitted to the *Journal of Soil and Water Conservation.*

Aspects of this research have been incorporated into Matt Helmers' Extension program. While presentations have not been focused solely on this project, the information learned about early spring storage capacity has informed various Extension presentations.

There were difficulties with the sap flow measurements as part of this project, but subsequent to this study and, in part based on learning experiences from this study, refinements were made to the procedures and these methodologies are being applied successfully by a graduate student to continue the study of plant transpiration of perennial and annual plant communities on another Leopold-funded project related to sap flow on STRIPS.

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Leveraged funds

The ISU environmental science program provided a half-time graduate research assistantship for the graduate student working on this project in fall 2009.

Information gathered in the collection of continuous soil moisture data has been useful to monitor soil moisture levels and was made possible with the types of sensors deployed as part of this work. This information was very useful in preparing subsequent grant submissions. Skills gained as part of this study have been used in the STRIPs program at the Neal Smith National Wildlife Refuge, the Corn-Based Climate Change: Mitigation and Adaption Coordinated Ag Project, and the Landscape Biomass project. As a result of skills gained from use of these soil moisture sensors, they have been installed at multiple sites throughout the Midwest United States.

For more information, contact:
Matthew Helmers, Agricultural and Biosystems Engineering, 219B Davidson Hall, Iowa State University, Ames, Iowa 50011; (515) 294-6717, e-mail mhelmers@iastate.edu